Region Search Optimization Algorithm for Economic Energy Management of Grid-Connected Mode Microgrid

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Abstract: Economic energy management of grid-connected microgrid has been widely investigated. However, due to the binary variables of the generation unit's status, the optimal result of the grid-connected microgrid is very hard. Thus, in this paper, the region search optimization algorithm (RSOA) is developed and adopted for the energy management of the grid-connected microgrid. The developed technique has higher convergence speed and accuracy, compared to the well-known heuristic techniques, such as genetic algorithm and particle swarm optimization. Results shows the effectiveness of the developed model.

Keywords: Grid-connected microgrid, economic energy management, industry microgrid,

I. Introduction

Small electricity network, known as the micorgrids, has been attracted lots of attentioans due to higher sustainability, resiliency, and reliability. In the microgrids (MGs) level of study, grid can be connected to the main grid and disconnected as well [1-10]. In the grid-connected mode, the microgrid can exchange energy with the upper level grid (main grid) [11-18]. That means, the microgrid can supply its demand not only by its own generation units, but also using the main generator in the main grid [19-23]. In contrast, in the islanded mode, the microgrid is disconnected from the main grid [24-32]. That means, the require power of the microgrid network should me met using the microgrid generation units. Although in the grid connected mode there exist more stability from the power supply perspective, the energy management of the entire system is very challenging.

For solving the grid-connected microgrid, many heuristic and mathematical models have been used and investigated, such as particle swarm optimization (PSO) and genetic algorithm (GA). However, these algorithms trap to the local minimum by increasing the size of the network. That means, by increasing the complexity of the system, these algorithms are not able to find the optimal solution. Also, using the mathematical technique will not contribute to the optimal solution. To this end, this paper developed and adopted a new heuristic technique that can overcome the drawbacks of the previous methods. It is worth noting that the heuristic techniques have been widely used in many researches, in several fields so far [20-32].

II. Mathematical Modelling of Connected Microgrid

Grid-connected main objective is to minimize the generation cost of units, as

$$min \sum_{\forall i}[C_i P_{it} I_{it} + SU_{it} + SD_{it}] \quad (1)$$

In (1), *I* is a binary variable 0 or 1, that controls the status of unit *i* at time *t.*

SU and *SD*: Startup and shutdown costs.

Please consider the following nomenclature for the rest of this paper.

UT, DT: Minimum up and down

$T_{(on)}$, $T_{(off)}$: Number of successive on and off hours

RU, RD: Ramp up and down of the generators.

Also, the grid-connected microgrid constraints are

$$P_{it,min} \le P_{it} \le P_{it,max} \tag{2}$$

$$P_{it} - P_{i(t-1)} \le RU_i \tag{3}$$

$$P_{i(t-1)} - P_{it} \le RD_i \tag{4}$$

$$T_{(on)it} \ge UT_i(I_{it} - I_{i(t-1)} \tag{5}$$

$$T_{(off)it} \ge DT_i(I_{i(t-1)} - I_{it} \tag{6}$$

This paper developed a new heuristic method known as the region search optimization algorithm for the grid-connected microgrid energy management, which is taken from [15]. Moreover, the mutation operator is adopted to increase the convergence speed of the algorithm.

III. Simulation Results

To show the merit of the algorithm for the grid-connected mode microgrid, the IEEE 69 bus test system, including 4 DGs has been tested, as shown in Fig. 1.

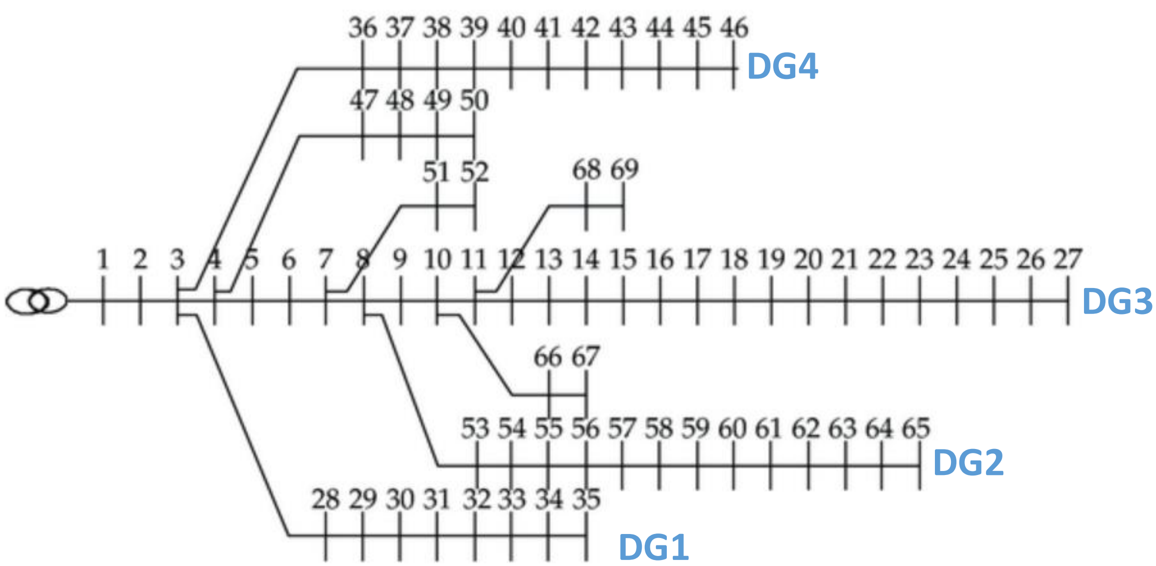

Fig. 1. IEEE 69 bus test system diagram

DGs feature are in Table I.

Table I
DGs features

	Minimum output power	Maximum output power
DG1	20	400
DG2	40	450
DG3	10	250
DG4	10	250

Load demand of the network are presented in Fig. 2.

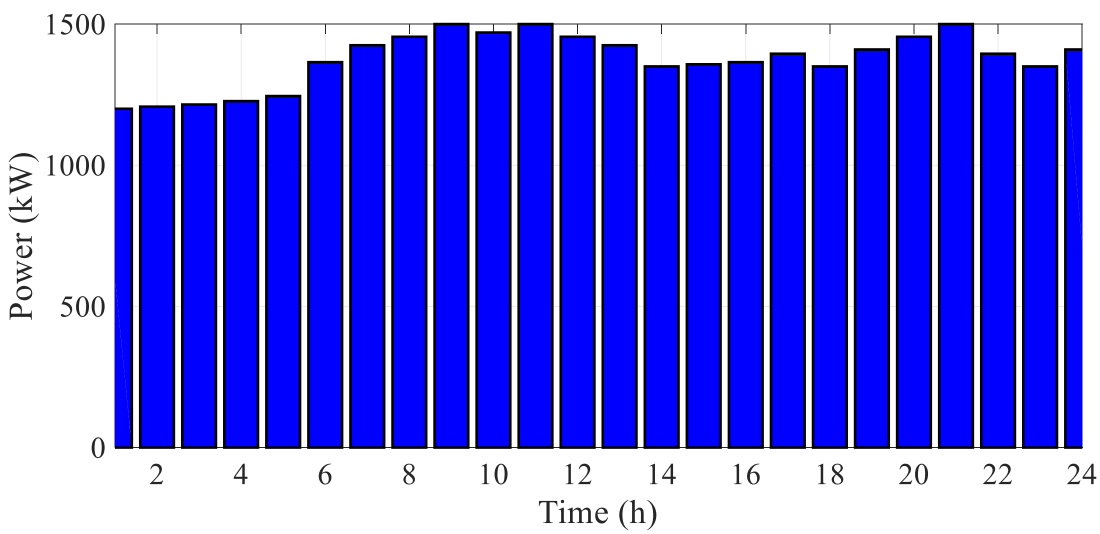

Fig. 2. Load demand of the network

DGs output power are mainly based on the economic perspective as shown in Fig. 4. The active DGs is the first DG where it has lower price.

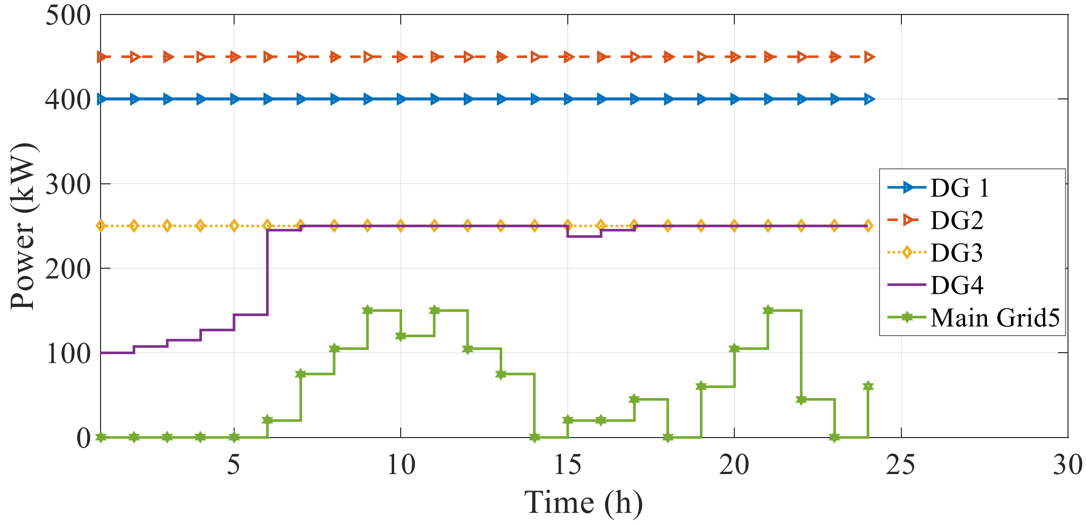

Fig. 3. Produced powers by DGs

Table II compare the operation cost and convergence speed of the algorithm. The results prove the effectiveness of the proposed model.

Table II

Cost of operation for several methods

	cost ($)	Convergence (s)
PSO	637335	11.1
GA	623437	9.9
Proposed method	512532	7.1

IV. Conclusion

Region search optimization algorithm is one of the powerful heuristics techniques that has been used in this paper for optimal energy management of the grid-connected MG. Results shows that compare to the PSO and GA, this method has higher convergence speed, which is one of the key points in grid-connected operation. In addition, it has lower operation cost for the microgrid operation compare to GA and PSO.

Reference

[1] Dabbaghjamanesh, Morteza, Boyu Wang, Shahab Mehraeen, Jie Zhang, and Abdollah Kavousi-Fard. "Networked microgrid security and privacy enhancement by the blockchain-enabled Internet of Things approach." In 2019 IEEE Green Technologies Conference (GreenTech), pp. 1-5. IEEE, 2019.

[2] Dabbaghjamanesh, Morteza, Abdollah Kavousi-Fard, Shahab Mehraeen, Jie Zhang, and Zhao Yang Dong. "Sensitivity analysis of renewable energy integration on stochastic energy management of automated reconfigurable hybrid AC–DC microgrid considering DLR security constraint." IEEE Transactions on Industrial Informatics 16, no. 1 (2019): 120-131.

[3] Kavousi-Fard, Abdollah, Boyu Wang, Omid Avatefipour, Morteza Dabbaghjamanesh, Ramin Sahba, and Amin Sahba. "Superconducting Fault Current Limiter Allocation in Reconfigurable Smart Grids." arXiv preprint arXiv:1905.02324 (2019).

[4] Wang, Boyu, Morteza Dabbaghjamanesh, Abdollah Kavousi-Fard, and Shahab Mehraeen. "Cybersecurity enhancement of power trading within the networked microgrids based on blockchain and directed acyclic graph approach." IEEE Transactions on Industry Applications 55, no. 6 (2019): 7300-7309.

[5] Dabbaghjamanesh, Morteza, Abdollah Kavousi-Fard, and Zhaoyang Dong. "A novel distributed cloud-fog based framework for energy management of networked microgrids." IEEE Transactions on Power Systems (2020).

[6] Dabbaghjamanesh, Morteza, Abdollah Kavousi-Fard, and Jie Zhang. "Stochastic Modeling and Integration of Plug-In Hybrid Electric Vehicles in Reconfigurable Microgrids With Deep Learning-Based Forecasting." IEEE Transactions on Intelligent Transportation Systems (2020).

[7] Dabbaghjamanesh, Morteza, and Jie Zhang. "Deep Learning-based Real-time Switching of Reconfigurable Microgrids." In 2020 IEEE Power & Energy Society Innovative Smart Grid Technologies Conference (ISGT), pp. 1-5. IEEE, 2020.

[8] Vasquez, Juan C., Josep M. Guerrero, Alvaro Luna, Pedro Rodríguez, and Remus Teodorescu. "Adaptive droop control applied to voltage-source inverters operating in grid-connected and islanded modes." IEEE transactions on industrial electronics 56, no. 10 (2009): 4088-4096.

[9] Zhang, Yan, Fanlin Meng, Rui Wang, Behzad Kazemtabrizi, and Jianmai Shi. "Uncertainty-resistant Stochastic MPC Approach for Optimal Operation of CHP Microgrid." Energy(2019).

[10] Chen, Yahong, Changhong Deng, Weiwei Yao, Ning Liang, Pei Xia, Peng Cao, Yiwang Dong et al. "Impacts of stochastic forecast errors of renewable energy generation and load demands on microgrid operation." Renewable Energy 133 (2019): 442-461.

[11] Khazaei, Peyman, Morteza Dabbaghjamanesh, Ali Kalantarzadeh, and Hasan Mousavi. "Applying the modified TLBO algorithm to solve the unit commitment problem." In 2016 World Automation Congress (WAC), pp. 1-6. IEEE, 2016.

[12] Sheikhrezaei, Kaveh. "Relating Individual Characteristics and Task Complexity to Performance Effectiveness in Individual and Collaborative Problem Solving." (2019).

[13] Haghshenas, S. A., Razavi Arab Azadeh (2014): Application of sediment constituent analysis for characterizing longshore sediment transport, case study of Ramin Port-Iranian coastline of the Oman Sea, the 16th Iranian Geophysics Conference – IGC16,Tehran, Iran.

[14] Razavi Arab, Azadeh, Danehkar A., Haghshenas S. A. (2012): Assessment of Coastal Development Impacts on Coral Ecosystems in Naiband Bay, the Persian Gulf, 33rd Coastal Eng. Conf., ASCE, Santander, Spain.

[15] Liu, Yongqi, Hui Qin, Zhendong Zhang, Liqiang Yao, Chao Wang, Li Mo, Shuo Ouyang, and Jie Li. "A region search evolutionary algorithm for many-objective optimization." Information Sciences 488 (2019): 19-40.

[16] Dabbaghjamanesh, Morteza, Shahab Mehraeen, Abdollah Kavousifard, and Mosayeb Afshari Igder. "Effective scheduling operation of coordinated and uncoordinated wind-hydro and pumped-storage in generation units with modified JAYA algorithm." In 2017 IEEE Industry Applications Society Annual Meeting, pp. 1-8. IEEE, 2017.

[17] Dabbaghjamanesh, Morteza, Abdollah Kavousi-Fard, and Shahab Mehraeen. "Effective scheduling of reconfigurable microgrids with dynamic thermal line rating." IEEE Transactions on Industrial Electronics 66, no. 2 (2018): 1552-1564.

[18] Dimeas, Aris L., and Nikos D. Hatziargyriou. "Operation of a multiagent system for microgrid control." IEEE Transactions on Power systems 20, no. 3 (2005): 1447-1455.

[19] Olivares, Daniel E., Ali Mehrizi-Sani, Amir H. Etemadi, Claudio A. Cañizares, Reza Iravani, Mehrdad Kazerani, Amir H. Hajimiragha et al. "Trends in microgrid control." IEEE Transactions on smart grid 5, no. 4 (2014): 1905-1919.

[20] Dabbaghjamanesh, Morteza. "Stochastic Energy Management of Reconfigurable Power Grids in the Presence of Renewable Energy by Considering Practical Limitations." (2019).

[21] Tajalli, Seyede Zahra, Seyed Ali Mohammad Tajalli, Abdollah Kavousi-Fard, Taher Niknam, Morteza Dabbaghjamanesh, and Shahab Mehraeen. "A secure distributed cloud-fog based framework for economic operation of microgrids." In 2019 IEEE Texas Power and Energy Conference (TPEC), pp. 1-6. IEEE, 2019.

[22] Taherzadeh, Erfan, Morteza Dabbaghjamanesh, Mohsen Gitizadeh, and Akbar Rahideh. "A new efficient fuel optimization in blended charge depletion/charge

sustenance control strategy for plug-in hybrid electric vehicles." IEEE Transactions on Intelligent Vehicles 3, no. 3 (2018): 374-383.

[23] Taherzadeh, Erfan, Shahram Javadi, and Morteza Dabbaghjamanesh. "New optimal power management strategy for series plug-in hybrid electric vehicles." International Journal of Automotive Technology 19, no. 6 (2018): 1061-1069.

[24] Pourbehzadi, Motahareh, Taher Niknam, Jamshid Aghaei, Geev Mokryani, Miadreza Shafie-khah, and João PS Catalão. "Optimal operation of hybrid AC/DC microgrids under uncertainty of renewable energy resources: A comprehensive review." International Journal of Electrical Power & Energy Systems 109 (2019): 139-159.

[25] Tsikalakis, Antonis G., and Nikos D. Hatziargyriou. "Centralized control for optimizing microgrids operation." In 2011 IEEE power and energy society general meeting, pp. 1-8. IEEE, 2011.

[26] Ashkaboosi, Maryam, Farnoosh Ashkaboosi, and Seyed Mehdi Nourani. "The Interaction of Cybernetics and Contemporary Economic Graphic Art as." Interactive Graphics (2016).

[27] Dabbaghjamanesh, M., A. Moeini, M. Ashkaboosi, P. Khazaei, and K. Mirzapalangi. "High performance control of grid connected cascaded H-Bridge active rectifier based on type II-fuzzy logic controller with low frequency modulation technique." International Journal of Electrical and Computer Engineering 6, no. 2 (2016): 484.

[28] Ashkaboosi, Maryam, Seyed Mehdi Nourani, Peyman Khazaei, Morteza Dabbaghjamanesh, and Amirhossein Moeini. "An optimization technique based on profit of investment and market clearing in wind power systems." American Journal of Electrical and Electronic Engineering 4, no. 3 (2016): 85-91.

[29] Sheikhrezaei, Kaveh, and Craig Harvey. "Relating the Learning Styles, Dependency, and Working Memory Capacity to Performance Effectiveness in Collaborative Problem Solving." In International Conference on Applied Human Factors and Ergonomics, pp. 53-64. Springer, Cham, 2019.

[30] Tajalli, Seyede Zahra, Mohammad Mardaneh, Elaheh Taherian-Fard, Afshin Izadian, Abdollah Kavousi-Fard, Morteza Dabbaghjamanesh, and Taher Niknam. "DoS-Resilient Distributed Optimal Scheduling in a Fog Supporting IIoT-Based Smart Microgrid." IEEE Transactions on Industry Applications 56, no. 3 (2020): 2968-2977.

[31] Ghaffari, Saeed, and Maryam Ashkaboosi. "Applying Hidden Markov Model Baby Cry Signal Recognition Based on Cybernetic Theory." IJEIR 5: 243-247.

[32] Ghaffari, Saeed, and M. Ashkaboosi. "Applying Hidden Markov M Recognition Based on C." (2016).